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ABSTRACT

The U.S. Department of Education is supporting a 3-year program involving Virginia Tech's computer department and a rural public elementary school. The project seeks to determine whether immersive access to networked computing by students and their families has measurable effects on long-term student achievement. A fifth-grade classroom was designed with a networked computer for every two students; the university is lending a computer for an extended time period to the family of each participating student. After training together, fifth-graders (randomly selected) work with parents on a child-centered curriculum that encourages reading, writing, exploration, collaboration, and critical analysis. Two control groups are used to assess long-term effects on student achievement. Preliminary findings suggest that the PCs for Families Program is well-regarded by both parents and children. Many children are strongly influenced by the program, and most experienced a renewed connection to learning. The technology has not built social capital, but helps families predisposed to active involvement. Researchers were unprepared for some families' weak parenting abilities and lack of competence. Next year, the program will stress family integration and parenting skills. Key program elements are discussed. (MLH)

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Home-School Networking to Support Constructivist Learning in a Rural Elementary School: Lessons from Families, Schools, and Researchers

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Abstract

A multi-year project is under way to study the long-term responses of children, families, and schools to a cost-free, technology-rich 5th-grade home and classroom environment. This paper presents preliminary experiences from the first half of the project and discusses some of the important considerations for conducting and evaluating such experiments.

Introduction

The US Department of Education is supporting a 3-year program in the Computer Science Department at our university in cooperation with a rural public elementary school. The project seeks to determine whether, under the best of circumstances, immersive access to networked computing by both students and their families has measurable effect upon long-term student achievement.

A 5th-grade classroom was designed with a networked computer for every two students, and the university is lending a computer for an extended period of time to the family of each student in the program. Fifth grade was selected because the children are still in their most vigorous learning phase, the "concrete operational" period, yet mature enough to master rather sophisticated strategies. That enables the students to work at home with their families in the same way that they do at school. We designed a child-centered curriculum to encourage reading, writing, exploration, collaboration, and critical analysis. Parents are being trained in networked computing along with their children, because family strength and support benefits the children (Barton and Coley, 1992; Coleman, 1991).

An important goal of the program is a longitudinal assessment of student achievement. This is of great national importance, since much is being invested in networked technologies, based upon unprecedented classroom successes with the new tools and information resources. However, it is not known to what extent student achievement is affected in the long term, perhaps 3 to 5 years later. Our experimental design uses two types of control groups to assess the long-term impact of the

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intervention on achievement. Group 1 consists of the 1996 and possibly the 1995 graduates of the school. Group 2 consists of 5th-graders selected from the entire school system, two for each student in the study group, on the basis of matches between the paired students. While the exact match metrics are yet to be determined, they will be based upon similarity of standardized achievement scores and whatever demographic information to which we may have access, such as the distance of their home from population centers, zoning, the size of their free lunch program, and so forth. Then, near the end of middle school, study and control group achievement scores will be compared.

We recognized from the start that the project would likely impact much more than the students' achievement. In particular, we expected the intervention to affect the learning process, the classroom social system, and family-school dynamics. In order to better understand these changes, we are gathering and archiving many different types of data. Parents and students regularly complete questionnaires about their computer abilities and family activities, and all students and parents, and staff members are interviewed. Student correspondence with the teachers and staff will be analyzed for changes in competency and literacy, and parent correspondence is being analyzed to understand how, and if, the new tools are affecting home-school relationships. A proxy server records WWW usage and Email traffic so that we may determine usage patterns; we are logging roughly 10 megabytes of data each week for our children and their families. Student writing samples are being collected, and the students are all tested for cognitive ability, learning style, and personality type.

Although we are not yet in a position to make claims about the long-term impact of our constructivist, technology-rich learning environment, we have learned much from our experience so far. In particular, we have learned much about the complexity of conducting controlled research within the environment of a *typical* school. In March 1997 a distinguished presidential panel issued a comprehensive report on the use of technology to improve K-12 education (Shaw, *et al.*, 1997). Section 8 of that report discusses some of the difficulties of conducting quality research on a scale sufficient to provide results that might guide national policy. Among the difficulties is that there is still insufficient formative research to develop hypotheses worthy of large-scale testing. Moreover, in order to perform large experiments it is often also necessary to create the intervention to be tested. This can be an extensive undertaking in itself, and it risks coupling the intervention with the design of its evaluation. We just don't know enough about which instructional designs might serve as reasonable national models or how to determine when they have been properly implemented and supported.

As one of the earlier small-scale programs to attempt to test a model for full technology-based classroom reform, we wish to share some of our experiences so that they may help guide those who follow us with even larger experiments. Our work has the added dimension of extensive family involvement which gives us considerable insight into the relationship between family dynamics and classroom learning in this technology-rich context.

Educating Students and Families

In our program, 24 students are selected randomly from the 5th-grade student population in our school. The selected families receive their PCs about 6 weeks after school starts; networking and support is provided free of charge as long as the project is funded. Subsequently, each child attends an after-school program for an hour a week, at which time technology relevant to classroom work is

taught. Also, each parent has the option of attending an evening session for an hour a week for the same reason. After graduation, each child moves on to a regular 6th-grade class at Auburn Middle School, which is adjacent to Riner Elementary school. The families retain their equipment at home, and the children have access to a computer laboratory and to a networked computer in each classroom.

In the 5th-grade classroom, the children are always within reach of their computer. They are taught that it is just another learning tool, like a book or a crayon. They use the computer for writing, communication, presentations, publication, research and reference, accounting, and for record keeping. Key to this approach is a partnership between the classroom teacher and a colleague who teaches the after-school program and provides technology support. Our teacher has had little formal technology training. Instead she has learned what she needs to know about technology through her relationship with her technology partner and about child-centered pedagogy and technology integration from a master teacher who served for a time as her mentor. The deeper concepts we try to convey to our children include ethical conduct, communication skills, and basic ability to be critical of the information they find as they work and explore. Like many other teachers who are using the WWW extensively, we hope we will be able to expand the children's global awareness beyond the boundaries of their small-town perspective.

Since the families are connected at home, we are also experimenting with collaborative technologies to learn how these might support learning outside the classroom. For example, we have provided our children with a WWW-based chat facility without enforcing its use. Recently a number of students (primarily our overachieving girls) have discovered that this is a novel way to hold evening group discussions about test and homework material. Now our technology specialist has joined in, which gives the children time that they don't have in the classroom to discuss issues with her beyond academics. Among their first questions: "Why does so many people play games during class?" As is well known, written communications may be more direct than face-to-face communications. While the novelty of this forum holds their interest, the children are practicing writing and learning to express themselves. From the log...

A: We sure are writing alot
B: Yes it is cool
A: Lets do this as much as possible
C: I know! We should set up a class time so all the fifth graders would come on at once!
B: ok
C: Do you think we should give the time to the boys?
A: That sounds great lets try it with everyone if not everyone at least the girls

Needless to say such words would please almost any teacher. This log fragment reveals a deep gender split in the classroom, the girls being far more mature and more academically oriented than the boys. In later conversation the girls reveal keen awareness of, if not disdain for the attitudes of the boys. We're still waiting to see how this chat group evolves, but at the time of writing, the girls seem to have claimed it as their territory. Most of the boys would not be able to express themselves as well as the girls have in this fragment.

Aside from what happens in our classroom, the district, the school, the teachers, and the children are quite unremarkable. The Riner, Virginia area is a bedroom farming community for Virginia Tech in nearby Blacksburg, and through random selection, the children and families in our group represent a

broad cross section of backgrounds and economic and educational levels. As for technology deployment, the county school system was fast off the starting blocks through its work in conjunction with the community network known as the Blacksburg Electronic Village. Recently, however, a cutoff in state technology funding and a reluctance of the county Board of Supervisors to increase taxes are making it difficult even to maintain the *status quo*. At the moment there is little prospect that the Montgomery County Public School system will achieve the technology levels prescribed by the presidential panel without external foundation support.

Not surprisingly, our families have a wide range of cultural backgrounds and competencies. Several families make little use of their home computers and will not even call for assistance when they have problems. One family has yet to appear for a single interview appointment, and another has had the telephone disconected. On the other hand we find that roughly half of the families are committed families who meet their obligations to provide us with data and support their children. Although the children seem to deal well with computers, we observed that perhaps four students from last year's class and two from this year's class just don't like them. Most of our students who are now in 6th grade continue to check their mail and use the WWW. However, several of our children have completely dropped their use of networking, while others who were headed for academic failure have become so engaged that their perspectives and goals have completely changed.

This year's class includes 6 to 8 behaviorally challenging boys (out of the 18 boys in this class) who have difficulty following instructions unless there is something especially novel about a particular lesson that catches their interest. Their urgent need for structured learning makes it difficult for the teachers to find partners for them to work with, to deal with the ensuing class disruption, and to give sufficient time to the other children who are thriving in the exploratory environment. We are observing more and more boys with the attitude that computers are for entertainment, and the principals tell us that more boys with disinterest in learning are coming from the lower grades. We're not sure why, and we were unprepared to deal with the social context that these children bring to the classroom. It may be that the proliferation of games in the home and elsewhere is strengthening the culture of reliance on external stimuli in which these children are growing up. On the other hand, we hear from other school districts that work avoidance and poor quality work are growing problems there as well.

Our learning styles inventory shows that the boys' learning styles are roughly as visual as the girls', with the girls actually being slightly more visual. There are three non-visual boys among our 18 this year. Assuming that computers are strongly visual, the learning styles of our children would not account for the behavior and attitude problems. Rather, these appear to be motivational problems, perhaps an indicator that social capital in the community is continuing to decline (Coleman, 1991). Of great interest to us is whether technology is so compelling that it can compensate for these effects. Another observation, also discussed by Smrekar (1996), is that many of our families are in job stress and find it difficult to find the time to work with their children and to fulfill their project obligations. In the Riner community, farming is declining, and many of the newcomers to the community do not have the traditional support from the extended family.

A number of children in each of our two classes have been extremely successful, including one of the most hyperactive children in the school. Some of the most important effects of technology deployment may be indirect, such as increasing self esteem, motivation, interest, and focus. Overall, we found tardiness decreased significantly from 4th grade, and we look for this trend to continue as

the students move onto 6th grade. Our students now perceive college as an important part of their future, with students rating the importance of college on average at 5.9 out of 6. They enjoy school and rank their enjoyment at 5.0 on a scale 0-6. 13 out of 16 children would consult the Internet if they needed to know what is playing at the local movie theater or the number of Virginia representatives in Congress. Most parents seem to be ardent supporters of technology deployment, even though they may neither posses significant technical skills nor directly support their child's educational development.

Interestingly, both children and teachers perceived substantially less effort by the parents in support of the program than did the parents themselves, with support declining as the year progressed. Possible clues about our observations come from Smrekar's (1996) excellent ethnographic studies of three types of schools (parochial, magnet, and public) which reveal vastly different degrees of parental commitment across the different schools and different attitudes toward active participation. In our project, computers were given to families who joined our classroom by random selection. There were no financial commitments or academic performance requirements for these parents. Therefore there is no special reason for them to feel a sense of ownership of the program or to increase their participation in school-related activities.

Research Partnerships

The Presidential panel report on educational technology stresses the importance of the conduct of large replicable studies of the use of educational technologies in the schools and emphasizes how little support is currently available to conduct the needed studies. The report also alludes to some of the difficulties of conducting quality studies. Therefore we attempt here to add some of our perspective on the problem of carrying out controlled studies due to significant cultural differences among the partners in such programs.

Research of this type is a huge undertaking, since one must deal with the physical classroom design, the instructional design, maintenance of the technical infrastructure, experiment design, data acquisition, data analysis, the Health and Human Services procedures for research involving human subjects, the sometimes exasperating politics of the school system, and the stresses on the teachers due to constant observation and interference by the researchers. It is unlikely that many model schools have interventions in place, ready for study, since nationally we are still exploring models that might make reasonable and implementable national objectives.

Unfortunately, schools have no *a priori* reasons to want to participate in research, unless they have internal motivation for self-improvement or sense that the projects will lead to new resources that will help to enhance organizational objectives. Internal motivation for change is rare. Schools are institutions, and like most are seldom motivated to change unless their survival is threatened (Hodas, 1993). Schools are usually well-established bureaucracies with no shortage of students and a long-history of mandated public endowment. Thus, research of this type, which systematically alters the structure of the classroom and its links to the outside environment, is often viewed as a threat unless committed participants internal to the school system can be recruited long before project inception. One of the difficulties is that researchers may enter into a research partnership with the schools without either party appreciating the scope, the invasiveness of the undertaking, and the commitment required. Building working partnerships is a lengthy process that requires substantial effort.

Until the recent technology thrust, schools tended to have relatively little interest in conducting empirical research; now school administrators who are scrambling to find funding sources realize that they cannot make credible cases to their boards without data to justify the efficacy of their technology expenditures. Still, few school systems embrace the research culture, and it is difficult to find in the schools truly committed research partners. Even when partners can be found, researchers from other disciplines often find their that their school partners consider research to be more a process of gathering subjective impressions than an experimental, empirically based evaluation.

Researchers and educators have very different backgrounds and training, and bring different perspectives and talents to the research process. These differences can strengthen the research process and make it a learning experience for all. Researchers find themselves learning things that educators well comprehend, such as, how poorly many families function and how that reflects on the classroom process. Educators find themselves playing catch-up in the technology arena and often rely on researchers to suggest methods for integrating networked computing into classroom processes.

Collaboration is essential; educators need to be full partners in the research design and measurement process. Just as the teacher participates in the design of the physical classroom, research design is best served by a participatory design process that involves administrators, teachers, and researchers. Educators can provide key insights into measurement costs and often will suggest new data sources unknown to the researcher. They also have excellent instincts about which measurements are most meaningful, and they need to determine how to implement data collection in a manner least disruptive to normal classroom functioning. Their participation is particularly important in a research project such as this, where research design is iterative due to the difficulty of fully understanding and predicting the quantitative impact of ubiquitous computing upon complex classroom and family dynamics.

The problems in working with the schools are numerous, and our experiences are remarkably similar to those described by David (1991) in the ACOT project. First, school personnel are increasingly under financial stress and time stress and may simply fail to respond to the needs of an invasive research project. Second, many school administrators see their mission as one of running the organization, and few seem to appreciate how directly their decisions and their support affect the learning of their children. As David puts it, "District staff are trained to generate and enforce rules... ." Technology is now forcing schools to be more interdisciplinary. Technology issues are so complex that most administrators, especially those whose education preceded the networked computing era of the '90s, are ill-prepared to deal with them. For example, they are beginning to realize that while a quality computing infrastructure is prerequisite to improved learning, it is quite inadequate by itself to ensure that learning will actually improve in the classrooms.

The schools must also respond to many diverse constituencies with often conflicting interests. When it comes to approving control groups for experiments, some administrators are reluctant to make decisions without school board approval, which gives research design a public aspect that researchers try at all cost to avoid. There are often internal school constituencies, such as the principals, that are sensitive about performance data. Researchers designing experiments have to determine who are in these constituencies and attempt to design experiments around them. Then there are issues of privacy and safety that concern all research with human subjects. University

researchers working with the schools also have to deal with Health and Human Services-mandated institutional review boards, with the result that experiment design is an exceptionally difficult and time-consuming process, even with school cooperation.

Research does not take place in isolation, and while educators wrestle with the responsibilities and burdens of the research process, they must simultaneously deal with the constraints and constituencies that all public institutions face, including publicly elected boards and officials. Since the schools have to respond to so many interests, including federal, state, and local government, it is unrealistic to count on long-term stability of any experimental design. Financial contingencies affect physical and personnel resources, changes occur in technology, and costing of critical services such as communications varies widely. Unexpected personnel turnover, changes in mandated standardized testing, and unexpected school reorganizations, all complicate, and sometime compromise, longitudinal studies. For instance, at the end of the first year of the project, the school's principal, who is both a principal investigator and an active participant in the integration process, was assigned to another school. Thus in this the second year, the project began the year with a principal who had no exposure to the project and who is only now, at the end of the second year, becoming a partner in the research process.

With so many parties participating in the research process, communications can be a serious obstacle. In the schools, just as in the general population, many teachers and administrators are unaccustomed to the culture of Email communications, and it is often the case that decision-making and information dissemination can be seriously impaired by those who still rely on telephones and personal contacts. Teachers especially have complicated schedules, and setting up a simple meeting or working out the details of a small project might take weeks. Sometimes decisions affecting the research project will not be communicated at all to the project personnel.

School personnel and teachers have widely differing reactions to the presence of researchers. Some find research an intrusion and are reluctant to aid in the collection of essential data. Others are extremely helpful and interested in the work. In many cases data collection can be invasive and increases the risk that observation will alter the results. Also, the purpose of measurement is often misunderstood to be a means of enforcing personal accountability in the school organization instead of a mechanism for scientific study. A participatory approach to research design helps allay participant fears, but building trust takes time, and a research methodology that ensures the privacy of students, families, and educators is the only solution.

There are also important situations where the presence of a research project can complicate an otherwise uncontroversial school process. Consider for example the problem of selecting children for our class who will receive almost $8,000 in benefits, per child. Rigorous experimental design mandates random assignment of students to treatment conditions, moderated perhaps by some blocking factor. However, schools don't use lottery-like mechanisms to compose classes. Not unreasonably, they design them much like organizations design teams with the student skills and social dynamics determining class membership. In our case, subject perceptions of equality may conflict with research objectives and turn an otherwise innocuous process into one sensitive enough to precipitate lawsuits.

In the PCs for Families project, the research partnership with the families is also important. In general our subject families have little concept of the research process and tend to lose sight of the

fact that the entire existence of the project is predicated upon their responsiveness. Students and their families can be an invaluable resource when experimenting with new technology or developing data collection instruments. Students especially delight in participating in evaluating data collection instruments in classroom survey sessions, often teaching the researchers as much about the quality of their instruments, as about the impact of the intervention itself.

Participating in research of this type is a real commitment for busy families, with research demands often taking much longer than expected. Finding families willing to make this sort of commitment is especially important in smaller-sized projects, such as this one, where the loss of several students can significantly impact the likelihood of detecting change using an experimental design. Longitudinal research of this type is even more difficult, requiring a long-term, in our case three to five year, commitment from families to remain in the local school district. Being up-front with families and explicitly stating the responsibilities of students and families is critical. Projects must also state the cost of the failing to meet its research commitments, be it expulsion from the project or removal of the computer from the home. Involving families in the research process before the school year begins can be especially helpful. Besides providing a solid baseline for the research, early introduction to the demands of the research allows students and families to better evaluate whether they have the time or the desire to participate. Families unwilling to make the necessary research commitment can drop out before the school year begins, thus allowing others to fill their slots. This minimizes disruptions during school year while maximizing the probability of obtaining the necessary data.

Researchers need to elaborate the research goals of the project, so that families understand the extent of the data researchers wish to gather. We have found that families are often surprised to be asked about non-computer aspects of family dynamics or to take surveys designed to assess the cognitive abilities of the parents. Many families focus on the technology aspects of the project and often assume that data collection efforts will be directly tied to technology usage or knowledge. They assume that the technology is neutral and without effect on the social or organizational functioning of the family.

Parents often view the time they spend providing information to researchers as time devoted to home-school communication. This may be a factor in the perceived drop in parental participation in the school process reported by students and teachers in the first year of the program. While our teacher felt that parental support generally does decrease as the year progresses, she also remarked on the lack of parental communication among our first year parents. While anecdotal information suggests that parent-teacher communication was low, further exploration is necessary. It may well be that information relayed through the children and information communicated through the project WWW pages might have resulted in a decreased need for personal communication.

Conclusions and Speculations

The PCs for Families program is well-regarded by both parents and children. Many of the children are strongly influenced by the program, and most in the first year experienced a renewed connection to learning. We did not expect that the mere presence of computers in the families would affect established family cultures in the short term. Even though there are signs that a number of families have begun to integrate networked computing into family process, it is still too early to draw conclusions.

We have not seen much evidence that the technology has served to build social capital. Rather, it seems to act as a facilitator to those families which are already predisposed to active involvement. Even in situations where the family is strongly supportive, it is difficult to determine whether the technology came as a supplement or as an agent of opportunity for change. As for the teachers, Coleman (1991) explains why many teachers are inclined to avoid unnecessary contact with parents. Our teacher, while always responsive, still does not initiate much out-of-classroom contact with children and families. In our project, the principal communicator has always been our technology support specialist.

We were not prepared for the weak parenting abilities and lack of competence of some of our families. Not surprisingly the children in these families also suffer from these weaknesses. We believe that networked computing offers great potential to strengthen both the families and the academic performance of their children. Next year we plan to focus on family integration and on teaching specific technology-supported parenting skills in an attempt to see whether through a more proactive involvement with the families, we can actually build social capital. For example, we are planning joint parent-child evening sessions in which the parents will be expected to do projects jointly with their children. We will be pre-testing these techniques this spring.

An additional explanation for the difficulties experienced by our low-performing boys is that they probably have not experienced a child-centered learning environment before and do not know how to manage the greater freedom. This suggests that isolated interventions may not be as effective as they might be in the context of a longer experience with constructivist learning. We are also working with the 6th-grade teachers to help them find ways to engage their students, our graduates among them, through the more limited networked computing resources they have available. Unfortunately they have not had much support and have numerous obstacles to overcome. David (1991) also believes, for yet other reasons, that it is better to transform entire schools than individual classrooms.

Finally, we argue that despite the need for large scale studies of schools or school systems that have achieved a level of networked computer technology integration, there is a need for rigorous and exhaustive smaller scale studies that can lend insight into the mechanisms through which technology can be effectively deployed to achieve specific effects.

Regarding the research process, key elements of a successful research-school-family partnership include

- a participatory approach to research design
- the need to view the research from the perspectives of the children, the teachers, the families, the school administrators, and the researchers themselves
- a commitment to the research process by all parties
- awareness of the research goals and plans
- good project communications
- willingness to make classroom and family processes visible
- involvement of educators and administrators in selecting the measures; often they'll be shouldering part of the collection burden.
- design of a research methodology that ensures the privacy of students, families, and educators.

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